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Research and Development and Cost Projections for Air Pollution Control Equipment

McIlvaine Co, Northbrook, Ill

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, N C

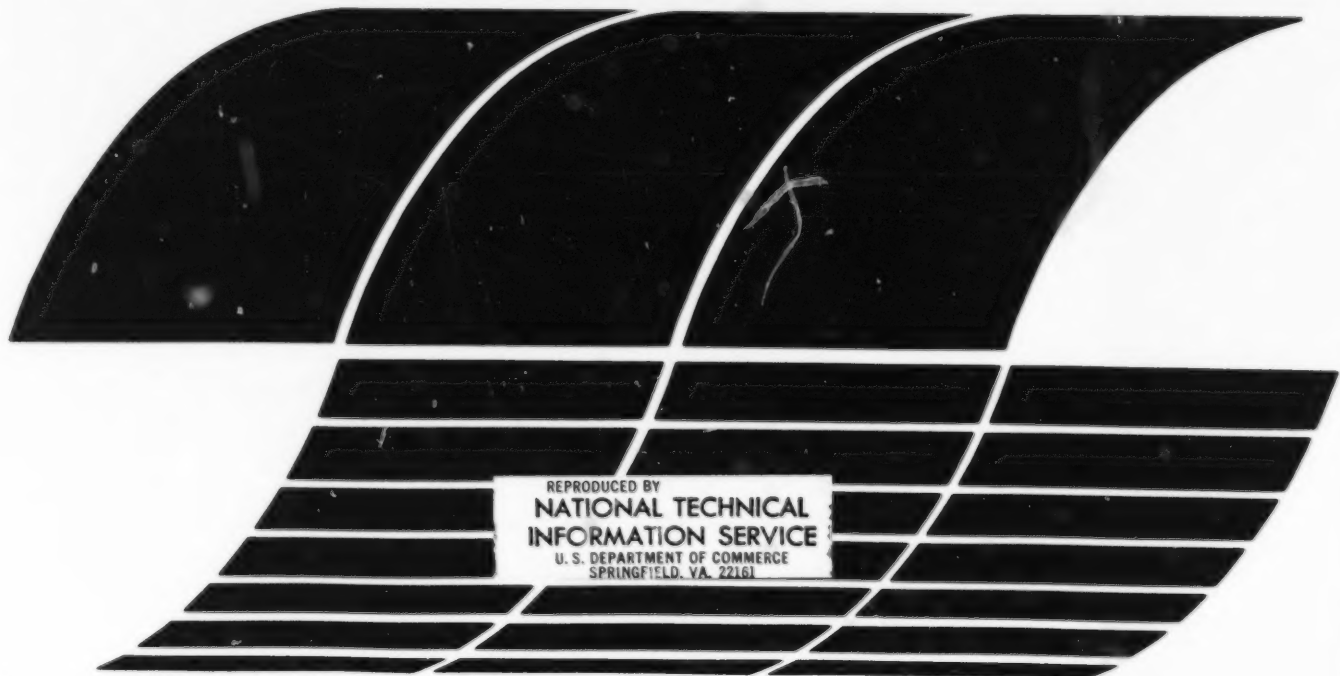
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Research and Development and Cost Projections for Air Pollution Control Equipment

**Interagency
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R&D Program Report**



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ABSTRACT

Utilizing a large and unique data base, the researcher has developed a methodology for projecting the installed cost of air pollution control equipment annually through the year 1982. Projections are made for the installed cost of fabric filters and electrostatic precipitators for the removal of particulate matter and for the installed cost of scrubbers for the removal of particulate and oxides of sulfur.

Similar projections are made for annual research and development expenditures by manufacturers of scrubbers, electrostatic precipitators, and fabric filtration systems.

Differences in the reported projections and those made routinely by other organizations are explained in light of the size of the researcher's data base, which is reported to be considerably larger than other similar data bases.

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SECTION I

INTRODUCTION

OBJECTIVE AND SCOPE

Most air pollution control equipment market forecasts are based upon projections derived from generally available data. Exceptions to this are the projections made by the Industrial Gas Cleaning Institute (IGCI) and the Department of Commerce (DoC) which are based upon data obtained from individual companies. However, both IGCI and DoC statistics are derived from a fairly limited sampling of manufacturers.

The McIlvaine Company, in pursuit of its publishing activities, has developed a large and unique data base that has been successfully employed to calculate installed costs and to project research and development expenditures in the air pollution control field. Data are obtained on a continuing basis from nearly every manufacturer of air pollution control equipment. Projections are thereby based upon a statistical population that approaches the real population. Thus differences between McIlvaine projections and those of other organizations should be weighed primarily in light of the size of the respective data bases.

GENERAL CLARIFICATIONS

There follows a discussion of the basic assumptions and certain specific clarifications that are necessary to understanding the material presented.

Prices

All prices given for 1977 and future years are reported in 1977 dollars. To obtain actual dollar values, an inflation factor should be added.

Chronology

Data are furnished relative to the year in which orders were placed, or in other words "bookings" as opposed to shipment year or year of operation.

Generally, the cash flow from purchaser to manufacturer begins within six weeks following the formal order placement and continues for months after installation of equipment. Purchasers often withhold as much as 10 percent of the total contract until the equipment is adequately demonstrated which would typically be six months after startup. Initial payments are made for engineering work on larger orders. Cash flow generally peaks around the time of shipment of the major components. Thus, actual cash flow figures are 6-18 months subsequent to booking figures. Booking figures have been used because they have a specific identifiable date, whereas shipment and startup dates are not readily identifiable.

Industrial Oxides of Sulfur

Figures for Industrial SO_x removal include only industrial boilers. Many other industrial sources will incorporate SO_x removal equipment. They include smelters, sulfuric acid plants and a wide variety of dryers, calciners and furnaces that use fuel with some sulfur. However, much of the pollution control equipment being operated is primarily removing particulates and other gases so that the removal of SO_x is accomplished along with the removal of other contaminants. Due to the diversity and lack of clarity estimates have not been segregated for non-boiler industrial SO_x but have been included with other pollutants.

Particulate

Particulate figures have been provided for the utility industry but industrial boiler particulate has been combined with other contaminants under "Industrial Air Pollution Control."

Flange to Flange Equipment Costs

This includes equipment (scrubber, fabric filter or precipitator) without auxiliaries or in other words, the purchase price of the device from the inlet to outlet flange. For example, the cost would not include the main air moving fan but would include fans used with fabric filters for reverse air cleaning of the bags.

Installed Costs

This includes equipment both primary and auxiliary, ductwork, foundations, engineering, startup service and electrical controls and liquid

clarification in the case of scrubbers. It does not include some other total investment costs such as interest on the investment during construction and preparation of the site.

Oxides of Nitrogen

A portion of this project involved projection of installed costs of NO_x flue gas treatment equipment as applied both to utility and industrial boilers. However, no individual figures have been furnished because it is the belief of the authors that no significant number of NO_x scrubbers will be purchased for this prior to 1983. A demonstration project is scheduled to be funded by the Environmental Protection Agency and will therefore result in the purchase and installation of some equipment. But, unless performance standards are instituted which would alter the present outlook, no substantial purchases are likely. Japan has placed considerably more emphasis on NO_x flue gas treatment and by contrast substantial equipment expenditures can be expected in that country during the period under examination.

Oxides of Sulfur

Figures are supplied for SO_x removal with scrubbers. Any SO_x removal with fabric filters or precipitators would therefore be in place of that projected for scrubbers. Presently, the only likely method of SO_2 removal with fabric filters is with the use of nahcolite. Other additives are considered to be either too expensive or not feasible with present technology. No nahcolite is presently available and no utilities are firmly committed to using nahcolite. After firm commitments are made, it will be three to four years before mines will be opened and material will become available.

The recent clean air amendments mandate best available technology. If it eventually is decided to exclude nahcolite injection, which at best only achieves 60-70 percent efficiency, then the amendments will have effectively eliminated this alternative. If, on the other hand, it is determined that nahcolite injection and fabric filters are an acceptable control technology, eventual sales will be increased since the amendments legislate desulfurization even on low sulfur coal installations.

SECTION II

CONCLUSIONS

1. A methodology has been developed to produce projections of future expenditures for research and development in the field of air pollution control equipment. A similar methodology has been developed to project estimates of installed costs of air pollution control equipment.
2. These methodologies have been employed to provide estimates of research and development expenditures in the fabric filter, scrubber, and precipitator industries for the years 1976 through 1982. Also, installed cost estimates for the years 1976 through 1982 are provided for the following specific applications:

	<u>Electrical Utilities</u>			<u>Other Industries</u>		
	<u>SO_x</u>	<u>NO_x</u>	<u>Part</u>	<u>SO_x</u>	<u>NO_x</u>	<u>Part</u>
Fabric Filter	X		X	X		X
Scrubber	X		X	X	X	X
Precipitator			X			X

SECTION III
RECOMMENDATIONS

The McIlvaine Co. recommends the EPA project officer use the research and development expenditures and installed cost forecasts presented in this report before referring to other published air pollution market projections and forecasts. It is believed that the projections presented here are more accurate because they are derived from a much larger data base than are those made by other market forecasters.

SECTION IV

INSTALLED COST PROJECTIONS - 1976 THROUGH 1982

INDUSTRIAL AIR POLLUTION CONTROL EQUIPMENT COSTS (Excluding Boiler SOx)

In order to determine installed costs for 1976 it was first necessary to determine flange-to-flange equipment costs. This was accomplished by obtaining actual figures in some cases, but more frequently from obtaining the CFM reported by manufacturers in publicity releases and other published data. This was supplemented by other data including sales estimates submitted by manufacturers. Costs for equipment were then derived based on a cost per CFM basis. This technique eliminated the need to use published installed costs which in reality are often total investment costs and therefore misleading.

It was determined that there were two distinct trends. One involved industrial boiler particulate control and the other involved other sources. With a new emphasis on coal use, it is projected that by 1985 over 33 percent of industrial energy will be supplied by coal-fired boilers as opposed to only 18 percent now being supplied. It was further assumed that precipitators would be furnished for 25 percent of the requirement for industrial boiler particulate control and that scrubbers would be used for 35 percent of the requirement and that fabric filters would be used for 40 percent of the required capacity. These estimates reflect the recent trend away from precipitators which have been historically used on this application.

It is projected that the nonboiler industrial segment will grow at a considerably slower rate. Fabric filters are projected to increase at an 11 percent rate, precipitators at a 10 percent rate and scrubbers at a 12 percent rate. Total yearly figures, therefore, reflect the combined increase of boiler and nonboiler expenditures. These figures are at odds with A. D. Little's 1975 projection of an 11 percent increase in particulate control equipment on a yearly basis from 1976 to 1985 and with Kidder Peabody's more conservative estimate of only 7 percent. However, the figures in table 1

TABLE 1. INDUSTRIAL AIR POLLUTION CONTROL EQUIPMENT COSTS
(Excluding Boiler SO_x)

	1976	1977	1978	1979	1980	1981	1982
	(Millions \$)						
FABRIC FILTER							
Nonboiler Expenditures	\$ 127.0	141.0	156.5	173.7	192.8	214.0	238.5
Industrial Boilers	2.0	5.0	8.0	12.0	20.0	30.0	42.0
TOTAL	129.0	146.0	164.5	185.7	212.8	244.0	280.5
SCRUBBER							
Nonboiler Expenditures	44.0	49.2	55.1	61.7	69.1	77.4	86.7
Industrial Boilers	1.0	2.0	3.0	5.0	6.0	8.0	12.0
TOTAL	45.0	51.2	58.1	66.7	75.1	85.4	98.7
PRECIPITATOR							
Nonboiler Expenditures	77.0	84.7	93.2	102.5	112.8	124.1	136.5
Industrial Boilers	5.0	7.0	9.0	10.0	11.0	12.0	13.0
TOTAL	82.0	91.7	102.2	112.5	123.8	136.1	149.5

reflect some of the impact of energy conversion mandated by the clean air amendments that was possibly not taken into account in the earlier studies.

Industrial boiler SO_x expenditures are given in table 6.

INDUSTRIAL EXPENDITURES

Flange-to-flange equipment costs from table 1 have been used to calculate installed costs based on the following multipliers: Fabric Filters 2.22, Scrubbers 4.5, and Precipitators 2.9. It is believed that these multipliers are accurate on an average basis even though there is a wide range for individual installations. Though flange-to-flange costs are the same, installation costs are often much higher for retrofit installations than for so-called green field installations. Size, materials of construction, and other factors also vary ratios between equipment and installed costs for individual installations.

TABLE 2. INDUSTRIAL EXPENDITURES

ORDER YEAR	FLANGE TO FLANGE (Millions \$)	INSTALLED COSTS (Millions \$)
FABRIC FILTER		
1976	129.0	286.4
1977	146.0	324.1
1978	164.5	365.2
1979	185.7	412.3
1980	212.8	472.4
1981	244.0	541.7
1982	280.5	622.7
SCRUBBER		
1976	45.0	202.5
1977	51.2	230.4
1978	58.1	261.4
1979	66.7	300.2
1980	75.1	338.0
1981	85.4	384.0
1982	98.7	444.0
PRECIPITATOR		
1976	82.0	237.8
1977	91.7	265.9
1978	102.2	296.4
1979	112.5	326.2
1980	123.8	359.0
1981	136.1	394.7
1982	149.5	433.6

UTILITY PARTICULATE CONTROL EQUIPMENT

Separate calculations have been made for new and retrofit installations. For particulate control on new boilers it has been assumed that

66,000 megawatts of high sulfur coal burning boilers will be ordered by 1982 for installation by 1985. It has further been assumed that 67,000 megawatts of low sulfur coal burning boilers will also be ordered by 1982. These figures are in agreement with those contained in the Temple, Barker & Sloane study.¹

Fabric filters are more likely to be used with low sulfur coal because of the higher resistivity which makes precipitation difficult. Also, when flue gas desulfurization is required, the precipitator-absorber or scrubber-absorber combination is more likely than a fabric filter-absorber combination. Therefore we project that the fabric filter will capture 45 percent of the low sulfur installations but 0 percent of the high sulfur installations. Precipitators will be used for 45 percent of the low sulfur installations and 85 percent of the high sulfur installations. Particulate scrubbers will be used for 10 percent of the low sulfur installations and 15 percent of the high sulfur installations.

In addition to new units, particulate control on 8,000 megawatts yearly of existing capacity has been estimated to bring units into compliance with local regulations and for normal replacement. Both high and low sulfur coal will be burned. In many cases, the additional particulate control will be required because of the switch from high to low sulfur coal. Consequently, we project 20 percent of these retrofit installations will include fabric filters, 10 percent scrubbers and 70 percent precipitators.

Although no scrubbers were purchased specifically for particulate control for utilities in 1976, Northern States Power has announced that it will install scrubbers rather than precipitators on an additional 1,500 megawatts. We believe this a beginning of a trend back to scrubbers for particulate control because of the much lower cost when particulate control and flue gas desulfurization can be combined.

Also of great significance is the trend toward using lower efficiency precipitators in systems where the precipitator precedes the flue gas desulfurization unit. In the system slated for Bruce Mansfield No. 3, there is a 95 percent efficient precipitator to be followed by an absorber that will remove SO_2 as well as capture 4-plus percent of the dust. This reduces the precipitator size and cost by a very substantial amount.

TABLE 3. UTILITY PARTICULATE CONTROL COSTS

YEAR	TOTAL MW 1,000	CFM IN MILLIONS	EQUIPMENT COST MILLIONS \$	INSTALLED COST MILLIONS \$
PRECIPITATOR				
1976			110.0	275.0
1977	10.8	50.76	139.6	348.7
1978	12.55	58.98	162.2	405.2
1979	19.0	89.3	245.6	613.5
1980	23.35	109.74	301.8	753.9
1981	26.4	124.08	341.2	852.4
1982	29.9	140.53	386.5	965.4
SCRUBBER				
1976				0
1977	1.8	5.4	9.5	37.8
1978	2.2	6.6	11.5	46.2
1979	3.3	9.9	17.3	69.3
1980	4.2	12.6	22.0	88.2
1981	4.8	14.4	25.2	100.8
1982	5.5	16.5	28.9	115.5
FABRIC FILTER				
1976	1.2	5.6	18.3	37.2
1977	3.4	16.0	51.9	105.5
1978	4.3	20.2	65.7	133.4
1979	5.65	26.6	86.3	175.3
1980	7.45	35.0	113.8	231.1
1981	8.8	41.4	134.4	273.0
1982	10.6	49.8	161.9	328.8

FABRIC FILTER SALES BY COMPANY SIZE

In 1976 the Industrial Gas Cleaning Institute reported only \$95 million in fabric filter orders whereas this study shows \$140 million--46 percent more. This \$140 million was derived from individual estimates of 100 companies. The top ten companies sold 62 percent of the total whereas the smallest fifty companies only sold 5 percent. But there were substantial quantities sold by the second and third tier companies. IGCI members included nine of the largest ten companies but only six of the second tier of ten companies and only four of the third tier and none of the fourth tier. It is believed that the figures in table 4 are consistent with IGCI data; but because IGCI reports only on activities of 20 percent of the companies, its figures are considerably lower than the actual industry totals.

UTILITY SO_x CONTROL

Orders for FGD equipment in 1976 were well over 1/2 billion dollars. The flange-to-flange scrubber sales were in excess of \$100 million. These figures are much greater than those reported by IGCI. Our figures were taken from reports in The Wet Scrubber Newsletters issued in 1976 and from

TABLE 4. FABRIC FILTER EXPENDITURES

COMPANY SIZE	TOTAL CFM (1,000's)	CFM x 1000 AVERAGE	EQUIPMENT COST (1,000's \$)	INSTALLED COST (1,000's \$)	% OF TOTAL
Top 10	43,428	4,343	86,856	192,820	62
2nd 10	12,936	1,294	25,872	57,435	18
3rd 10	5,502	550	11,004	24,428	8
4th 10	3,304	330	6,608	14,670	5
5th 10	1,538	154	3,076	6,828	2
51-100	3,750	75	7,500	16,650	5
TOTAL 100			140,916	312,831	

data compiled by PEDCo in their bi-monthly report to EPA. Totals of individual reports from the newsletter agree with the general figures supplied by PEDCo and are therefore believed to be accurate.

IGCI figures are lower than actual sales because, (1) a number of large flue gas desulfurization equipment manufacturers do not belong to IGCI, (2) IGCI has recently formed an FGD division; and there may be some problem in reporting because of the two categories (wet scrubbers and flue gas desulfurization) under which an order could be classified.

Projected orders for new equipment are based on the assumption that 156,000 MW of FGD systems will be required by 1985 but that only 70 percent of the required systems will be ordered by 1982. This is based on the assumption that all new low sulfur coal-fired boilers will also require FGD systems since the passage of the new Clean Air Amendments.

The forecast assumes that orders for FGD systems will peak in 1982. Orders placed in that year will result in installations operating in 1985. Since noncompliance penalties are to be imposed, it is assumed that the bulk of the orders will be let in time to avoid such penalties.

TABLE 5. UTILITY SO_x CONTROL EXPENDITURES

Order Year	Compliance Year	MW × 1,000	Saturated CFM × 1,000	Flange-to-Flange Scrubber Cost (Millions \$)	Installed Cost SO ₂ System (Millions \$)
1976	1979	11	33,000	101	674
1977	1980	8	24,000	72	480
1978	1981	12	36,000	108	720
1979	1982	18	54,000	162	1,080
1980	1983	20	60,000	180	1,200
1981	1984	24	72,000	216	1,440
1982	1985	27	81,000	243	1,620

INDUSTRIAL BOILER SO_x CONTROL

This market segment is very difficult to forecast because most industrial companies are uncertain as to their plans. The biggest unknown is whether they will use low sulfur coal. Although the shift to coal in general is viewed as inevitable, the timing may be subsequent to the forecasting period for some. It is assumed that new high sulfur coal installations will utilize FGD equipment and that some older systems and some new lower sulfur coal installations will also have FGD systems although the latter number will be quite small.

As with the utility segment, it is forecast that the orders for these systems will peak in 1982, based on compliance dates of 1984-85.

TABLE 6. INDUSTRIAL BOILER SO_x CONTROL EXPENDITURES

Year	MW	CFM × 1000	Equipment Cost (1,000's \$)	Installed Cost (1,000's \$)
1976	200	600	1,800	19,800
1977	400	1,200	3,600	39,600
1978	1,000	3,000	9,000	99,000
1979	2,000	6,000	18,000	198,000
1980	3,000	9,000	27,000	297,000
1981	5,000	15,000	45,000	495,000
1982	7,500	22,500	67,500	742,500

TOTAL INSTALLED COSTS FOR AIR POLLUTION CONTROL EQUIPMENT

Because of the large investment in flue gas desulfurization equipment, scrubbers represented over 50 percent of all expenditures in 1976. This figure is projected to be slightly less than 50 percent in 1977, but to increase to 55 percent by 1982. Precipitators will continue to lead fabric filters but not by the historically wide margins of the past. In 1982, expenditures by utilities will comprise 60 percent of the total expenditures.

TABLE 7. INSTALLED COSTS OF AIR POLLUTION CONTROL EQUIPMENT
(1,000's \$)

	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
FABRIC FILTERS							
Utility Part.	37,224	105,468	133,386	175,263	231,099	272,976	328,812
Ind. Part.	286,400	324,100	365,200	412,300	472,400	541,700	622,700
Total	323,624	429,568	498,586	587,563	703,499	814,676	951,512
SCRUBBERS							
Utility Part.	0	37,800	46,200	69,300	88,200	100,800	115,500
Ind. Part.	202,500	230,400	261,400	300,200	338,000	384,000	444,000
Utility SO _x	674,000	480,000	720,000	1,080,000	1,200,000	1,440,000	1,620,000
Ind. SO _x	19,800	39,600	99,000	198,000	297,000	495,000	742,500
Total	896,300	787,800	1,126,600	1,647,500	1,923,200	2,419,800	2,922,000
PRECIPITATORS							
Utility Part.	275,000	348,700	405,200	613,500	753,900	852,400	965,400
Ind. Part.	237,800	265,900	296,400	326,200	359,000	394,700	433,600
Total	512,800	614,600	701,600	939,700	1,112,900	1,247,100	1,399,000
Total Equip.	1,732,724	1,831,968	2,326,786	3,174,763	3,739,599	4,481,576	5,272,512

A DISCUSSION OF DISCREPANCIES WITH OTHER PUBLISHED DATA

The Bureau of the Census issued its figures for 1976 in August 1977.² There is a substantial difference between their estimates of orders received, those presented in this report, and those of IGCI. The difference between IGCI and Census figures can be only partly explained by differences in the numbers of companies reporting. Only two very large precipitator manufacturers do not belong to IGCI, yet 1976 orders reported by IGCI are less than 50 percent of the \$280 million reported by the Bureau of the Census.

The Bureau of the Census figures are based on flange-to-flange equipment as are the IGCI figures. However, according to a Census spokesman, the forms they send out are mailed to accountants who tend to submit total contract prices rather than flange-to-flange prices. In fact, Census encourages the reporting of available figures like contract prices rather than imputed figures such as flange-to-flange prices that require difficult calculations. Therefore, despite the fact that our estimates of 1976 precipitator orders are considerably less than those of Census, it is believed that the estimates presented are more representative.

Coincidentally, our figures and those of Census for fabric filters are very close even though theirs are for 36 companies and ours are for 100. Again, it is felt that this is because installation figures are included in some of the Census numbers.

Our figures on scrubbers are higher. Again it is felt this is because Census did not include scrubber orders of multiproduct companies such as Combustion Engineering that are now quite active in flue gas desulfurization systems. Our figures are for 150 companies, and Census included only 36 scrubber companies.

SECTION V
RESEARCH AND DEVELOPMENT EXPENDITURES - 1976 THROUGH 1982

SURVEY PROCEDURES

Manufacturers of air pollution control equipment provide only a portion of the research and development activity on their devices. Purchasers of equipment either independently or through their associations do a substantial amount of research and development of control equipment. This frequently takes the form of grants or funding of demonstration projects by manufacturers. University research in these fields is also funded by purchasers.

Governmental bodies, and specifically the Environmental Protection Agency, fund a great deal of research and development. Some of this work is done by EPA personnel, but a larger quantity is performed by contractors. These contractors include manufacturers, engineering firms, private researchers, universities and nonprofit institutes.

This study includes only those expenditures by equipment manufacturers; however, the expenditures by the other above mentioned organizations are more than equal to manufacturers' expenditures. For instance, the Electric Power Research Institute has budgeted \$55 million in research and development expense for air quality control for the next five years. This is equivalent to 40 percent of the entire amount to be spent by the manufacturers; but since much of the EPRI work will be subcontracted to those same control equipment manufacturers, the manufacturer's role is substantially greater than that reflected in their research and development expenses. These contract expenditures are treated as normal cost of sales associated with revenue producing contracts.

Another type of research and development is extremely common but not easily identified. Manufacturers incorporate new ideas into actual full scale installations. In effect, the customer pays for the research and development. The jump from the idea to the full scale trial often results

in expenses to the manufacturer in terms of field service labor and material changes which are again treated as normal cost of sales.

To determine the actual research and development expenses by manufacturers, a survey was conducted. Approximately 150 companies were sent a questionnaire which is included as appendix A. Manufacturers were asked to supply figures on R & D expenses for two years - 1977 and 1982. These figures were expressed as a percentage of flange-to-flange equipment sales. The tabulation of the results of this study are shown in tables 8 through 13.

SURVEY RESPONSE

A high percentage of the precipitator manufacturers responded to the survey, but a relatively small percentage of fabric filter and scrubber manufacturers responded. Individual responses are shown in table 8. This is possibly because IGCI has recently conducted a survey of precipitator manufacturers and they had the information more readily available.

Several very high percentages reported by a few manufacturers of scrubbers and fabric filters could distort the totals. However, it is believed that this does represent a true picture in that a few companies tend to be the innovators. These few do a disproportionate amount of the research and development. The philosophy of the other companies is that it is better to let their competitors (frequently smaller companies) do the innovating and that it is safer and more profitable to follow rather than lead.

Table 8 also indicates that scrubber and fabric filter expenditures are considerably higher than precipitator expenditures. It is not expected that the precipitator industry will continue to expand. As a result, precipitators will gradually give way to other control methods. It is the anticipation of this trend that has caused and will continue to cause companies to reduce expenditures for precipitator research.

United States precipitator manufacturers are doing less research and development than their foreign competitors. This may in part explain the substantial inroads made by foreign companies in the U.S. market.

R & D EXPENDITURES BY MANUFACTURING GROUP

Tables 9, 10, and 11 list expenditures by groups. More than half the companies are spending less than 2 percent of equipment sales on research

TABLE 8. PERCENT OF FLANGE-TO-FLANGE COST SPENT ON
R & D BY EACH REPORTING COMPANY

<u>SCRUBBER</u>		<u>FABRIC FILTER</u>		<u>PRECIPITATOR</u>	
1977	1982	1977	1982	1977	1982
1	-	1	2	0	0
1	2	2	2	0	.5
1.82	2	2	2.5	.4	.5
2	2	3	1.5	.9	3
2	2	3	3.5	1.9	1.5
2.1	2	<u>22</u>	<u>6</u>	2	.35
4	1.5	5.5	2.9 Average	2	1
4	6			2	2
5	2.5			2	2
5	3			2	3
11	2			<u>6.3</u>	<u>3</u>
25	10			1.8	1.5 Average
<u>25</u>	<u>20</u>				
6.84	4.6 Average				

TABLE 9. R & D EXPENDITURES BY SCRUBBER MANUFACTURERS

Percent From Table 8	<u>1977</u>		<u>1982</u>	
	<u>Companies</u>	<u>Percent of Total</u>	<u>Companies</u>	<u>Percent of Total</u>
0 - 1%	2	15	0	0
1 - 2%	3	23	7	58
2 - 5%	5	38	2	17
5 + %	3	23	3	25

TABLE 10. R & D EXPENDITURES BY PRECIPITATOR MANUFACTURERS

Percent From Table 8	1977		1982	
	Companies	Percent Of Total	Companies	Percent Of Total
0 - 1%	4	36	4	36
1 - 2%	6	55	4	36
2 - 5%	0	0	3	27
5 + %	1	9	0	0

TABLE 11. R & D EXPENDITURES BY FABRIC FILTER MANUFACTURERS

Percent From Table 8	1977		1982	
	Companies	Percent Of Total	Companies	Percent Of Total
0 - 1%	1	17	0	0
1 - 2%	2	33	3	50
2 - 5%	2	33	2	33
5 + %	1	17	1	17

and development. Since the average contract is several times the control equipment sales price, research and development expenses expressed as a percent of total sales are less than half the percentages shown in the charts.

ANNUAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT

Tables 12, 13, and 14 show the actual dollar expenditures for research and development year by year for each of the three types of control equipment. 1977 expenditures for the three types are \$23 million expanding to \$41 million in 1982. Note, however, that the expenditures as a percent of sales are anticipated to decline. This is probably because of the belief by the manufacturers that the market will not keep accelerating in the late 1980s.

The approach used for tables 12 through 14 in the research and development analysis has been made on a strictly statistical basis. The replies received from manufacturers were assumed to be representative of both the mean and average expenditure.

TABLE 12. YEARLY R & D EXPENDITURES BY SCRUBBER MANUFACTURERS

<u>Year</u>	<u>Equipment Sales (Millions \$)</u>	<u>Percent R & D</u>	<u>R & D Expenditures (Millions \$)</u>
1977	136.3	6.84	9.3
1978	186.6	6.39	11.9
1979	264.0	5.94	15.7
1980	304.1	5.49	16.7
1981	371.6	5.04	18.7
1982	438.1	4.60	20.2

TABLE 13. YEARLY R & D EXPENDITURES BY PRECIPITATOR MANUFACTURERS

<u>Year</u>	<u>Equipment Sales (Millions \$)</u>	<u>Percent R & D</u>	<u>R & D Expenditures (Millions \$)</u>
1977	231.3	1.80	4.2
1978	264.4	1.74	4.6
1979	358.1	1.68	6.0
1980	425.6	1.62	6.9
1981	477.3	1.56	7.4
1982	536.0	1.50	8.0

TABLE 14. YEARLY R & D EXPENDITURES BY FABRIC FILTER MANUFACTURERS

<u>Year</u>	<u>Equipment Sales (Millions \$)</u>	<u>Percent R & D</u>	<u>R & D Expenditures (Millions \$)</u>
1977	197.9	5.5	9.9
1978	230.2	5.0	11.5
1979	272.0	4.5	12.2
1980	326.6	4.0	13.1
1981	378.4	3.5	13.2
1982	442.4	2.9	12.8

POSSIBLE SURVEY DISCREPANCIES

It is quite possible that the survey reflects mean expenditures accurately while not reflecting average expenditures. This is because the size of each company reporting was not identified. Small companies entering the field have high research and development expenses relative to sales. However, the total gross expenditure is small compared with that of the larger manufacturers.

To pursue this approach additional calculations were made as shown in table 15. Percentage averages were recalculated by eliminating the highest reported expenditures. In the case of scrubbers two figures were excluded. One each was dropped from the fabric filter and precipitator groups. This approach substantially reduces projected 1977 expenses and also has an important but lesser effect on 1982 expenditures.

To further study the validity of this hypothesis a supplemental study would be required in which sizes of reporting companies are identified. This could be somewhat difficult because of the reluctance of companies to reveal dollar numbers as opposed to percentage figures.

TABLE 15. ADJUSTMENTS TO R & D EXPENDITURES DUE TO
SURVEY DISCREPANCIES

	1977		1982	
	<u>Percent</u>	<u>\$ millions</u>	<u>Percent</u>	<u>\$ millions</u>
Scrubbers	3.5	4.8	2.5	10.9
Fabric Filters	2.2	4.4	2.3	10.2
Precipitators	1.3	3.0	1.4	7.5

REFERENCES

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3. Various statistics reported by the Industrial Gas Cleaning Institute.
4. U.S. Department of Commerce. U.S. Industrial Outlook. January 1977.
5. The McIlvaine Company. Wet Scrubber Newsletters, Fabric Filter Newsletters and Precip Newsletters.
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APPENDIX A
RESEARCH AND DEVELOPMENT EXPENDITURE QUESTIONNAIRE

ELECTROSTATIC PRECIPITATOR

Research and Development Expense Estimate

TO: McIlvaine Company

Definition of Research and Development: Projects not associated specifically with sales where anticipated revenue is a significant portion of the total (in other words exclusion of R & D with customers' money) where the primary goal is the improvement of the precipitator or the improvement of the air pollution control process in which the precipitator is an integral part. In other words pilot testing to determine applicability of a device to a process would be considered R & D but only if the purpose were general and not part of a specific proposal for the pollution source being piloted.

Definition of Cost of Research and Development: Yearly R & D expense divided by yearly sales of precipitators on a flange to flange basis expressed as a percent. In other words if precipitators R and D for 77 is \$50,000 and flange-to-flange precipitator sales are \$2,000,000 then R & D cost percent would be 2 and 1/2 percent.

Estimates: Estimated 1977 Research and Development cost for precipitators by my company expressed as a percent of flange to flange sales _____ percent.

Estimated 1982 Research and Development cost for precipitators by my company expressed as a percent of flange-to-flange sales _____ percent.

Tear off and send bottom half separately if complete anonymity is desired. I have replied to the R & D questionnaire. Please see that I receive the general published results.

Name _____

Company _____

Address _____
